Study: Nation's air-transportation system must become more 'agile'

October 5 2006

Researchers at Purdue University have created a mathematical simulation that could be used in a new national strategy to ease airport congestion and improve the overall transportation system.

The simulation was created as part of research with NASA to develop "a robust, scalable transportation system concept" that would be more resilient and better able to withstand factors such as severe weather, equipment malfunctions and shifting future demand, said Daniel DeLaurentis, an assistant professor of aeronautics and astronautics.

The study covers various aspects of the nation's air transportation system and takes into account the possible benefits of introducing a new class of small, lightweight jets that could share the load now handled by commercial airliners, reducing congestion at major airports. Companies using these jets are forming air taxi services that could be based at the nation's thousands of small airports to ferry passengers between cities.

"There have been other studies of next-generation air transportation systems, but they typically focus on particular aspects or details, such as the need for a certain kind of airplane, radar system or runway additions at large airports," DeLaurentis said. "What we do in this study is look at technological, economic and policy factors simultaneously, and that was our unique starting point."

A report based on the research was completed earlier this year and submitted to NASA, the sponsoring agency. Report findings include

recommended policy changes, as opposed to concentrating exclusively on upgrading technologies.

The researchers took a first-of-its-kind "system of systems" approach, or a method of analyzing a complex system that is made up of many component systems, to study airport issues, DeLaurentis said.

An interdisciplinary team of faculty members and students in civil engineering, aerospace and computer science created the simulation, said DeLaurentis, who led the research. The researchers combined two new mathematical techniques called agent-based modeling and network theory to integrate all of the components within the air transportation system and predict overall performance. The model mimics the behavior of service providers, such as the major airlines and small air taxi companies, along with the infrastructure providers, such as the Federal Aviation Administration and U.S. Department of Transportation.

"You can almost think of it as a video game where the service providers are adding flights and subtracting flights and doing the best they can to satisfy changing demand, and the FAA is trying to catch up and add the capacity necessary to meet the needs of the airlines," DeLaurentis said. "One of the findings was that if the infrastructure providers were not able to keep pace with demand, the service providers would stagnate. They would be unable to add the flights that they needed. Yet, such agility or responsiveness is critical.

"Improving agility, we found, requires not so much that you build a brand new runway at every large airport. You need to be able to add capacity in a variety of other quicker ways. One of the problems in the current system is that it takes so long to develop new capacity at a major airport that by the time the capacity is available, the demand has already changed."

One factor in the system's current sluggishness is that policy changes are needed to help streamline the system, he said.

"There are various air-traffic management technologies that are always coming up, but historically it's been difficult to implement them in a timely manner - not necessarily because the technology is poorly understood, but because the rules and policies of how they are to be used and when they are to be used just don't develop fast enough," DeLaurentis said.

The simulation could help to make the system more agile because it could be used by the FAA and other infrastructure providers to weigh various options for meeting the demands of industry proposals to increase service at a particular airport, he said.

The current system is plagued by a lack of strategic planning and coordination among service and infrastructure providers, he said.

"I would say that the airlines and other service providers are operating on a different time scale than the FAA," DeLaurentis said. "The FAA is thinking of developing capacity in terms of a 10-year time frame, but the service providers and the customer base that generates demand are changing decisions every three months, so there is a mismatch. A more agile system would have a closer connection between the two time scales."

Also needed is better coordination among the different airlines and emerging air taxi companies.

"If you think about the air transportation network, it's actually just a collection of sub-networks run by the airlines," DeLaurentis said. "The different airlines are totally separate networks, even if they operate at the same airport."

More coordination among the different carriers would help make the system more agile by better enabling an airline experiencing serious problems to reroute passengers on flights operated by a competing airline, he said.

A key portion of the research delves into a national plan to take advantage of an estimated 5,000 "underutilized airports" across the nation, dozens of which are located in Indiana, using fleets of "very light jets." The jets could be used in a nationwide air taxi system based at small airports because the planes can take off and land on shorter runways than commercial jets. The air taxi system could alleviate demand and reduce congestion at major airports.

"Not only does it offload demand from the busy hubs, but it actually could give a better doorstep-to-destination experience for the traveler," said Srinivas Peeta, a professor of civil engineering at Purdue and director of a new regional transportation research center. "If you can board a very light jet close to where you live and get off close to where your destination is, then total travel time savings could be substantial."

Air taxi services could be located at Purdue's airport, for example, and passengers could book flights directly to Detroit and other relatively nearby cities.

"Today, if I want to go from West Lafayette, Ind., to Detroit, I have to drive to the Indianapolis airport, which takes an hour, get on a commercial airliner, connect in Chicago and then take another flight to Detroit," Peeta said. "Whereas, if you had this regional system of air taxis, I would just make the five-minute drive to the local airport and fly to a small airport near my destination."

The air taxi concept lends itself to consumer-driven scheduling, unlike the rigid schedule of traditional airlines.

The small jets hold about eight people, including the pilots, whereas business jets carry about 12 people and the smallest commercial regional jets hold 40-80 passengers. New companies are forming to meet the emerging market for very light jets, and one company has had its jet certified by the federal government, Peeta said.

The jets can fly at speeds approaching those of commercial airliners, but have lower operating costs and maintenance overhead.

Although many small airports lack sophisticated air-traffic control capabilities, the small jets will eventually be equipped with "automatic dependent surveillance broadcast" systems, which provide pilots with a constant fix of other nearby planes, DeLaurentis said.

"If I were flying into a small airport, the system would allow my aircraft to automatically communicate with all of the other planes in the airspace so that I would have the same awareness of ground radar controllers at large airports," DeLaurentis said.

Without the technology, small airports can't allow landings and departures to take place simultaneously.

"You typically have to do one-in, one-out at small airports, which means you have to wait until the plane taking off clears the airspace before you can land an incoming plane," he said.

A potentially major economic benefit of the air taxi services is that they would give corporations increased access to rural areas, where operating costs are typically lower than in large metropolitan areas, said Bob Wearley, president of Indiana Strategic Air Transportation Services. INSATS, formerly called Small Aircraft Transportation Systems, is a research and development program conducted through a public-private partnership jointly managed by NASA, the FAA and the National

Consortium for Aviation Mobility. The program seeks to integrate the use of small aircraft into the mass transportation system.

"Very light jets would make moving facilities to rural areas much more attractive for companies," Wearley said. "The air taxis would introduce affordable flights and provide several economic development benefits to a state or region. They would attract service providers and aircraft manufacturers, encourage the development of ancillary business to support the new air taxi services, and serve as a tool for economic development agencies, as well as city and county officials, airport operators, and so on, for business retention and recruitment."

A potential obstacle, however, is that current policies are not entirely favorable for introducing the air taxi concept, Peeta said.

"A paradox is that for air taxi companies using very light jets to make money they have to have the flexibility for the jets to be integrated rapidly into the air transportation system, but current air traffic control policies may hinder that integration," Peeta said. "On the other hand, you are not going to get the government to change the system without showing the viability of the service. It's a chicken-and-egg problem."

Findings from the study will be used by both NASA and the FAA.

The researchers plan to expand the model to include other modes of transportation, such as cars, trucks and trains so that the simulation would predict a doorstep-to-destination scenario for travelers and freight, DeLaurentis said.

"Generally speaking, we feel there is something to be learned by looking at possible coordination between the different types of service providers," he said. "In other words, changes in the air transportation system could affect the ground transportation system, or vice versa.

That's extremely important but a difficult research challenge, but hopefully we are going to tackle that."

Source: Purdue University